

# Student assessment of their mathematical education in a postgraduate course in administration

## Valoración estudiantil sobre su formación matemática en un posgrado en administración

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### ABSTRACT

#### Keywords

Students; emergency remote teaching; mathematical training; postgraduate; professorate; student evaluation

The objective of the research was to assess student satisfaction regarding their mathematical education in a postgraduate course in administration based on remote teaching during the covid-19 pandemic. The research approach was mixed with a sequential exploratory design. A questionnaire was developed and administered to 65 participants about the type of technological devices used, the challenges faced, and students' assessment of their level of mathematical education. The results showed that students acknowledged experienced logistical, emotional, and academic challenges during the emergency period. Statistically significant differences were also found because remote teaching promoted mathematical education through effective use of video conferencing, enabling the integration of learning into professional performance, assisting in course planning and adaptation explained by the faculty, and benefiting from the use of virtual databases and asynchronous communication. Additionally, the students rated competences related to administrative situations, mathematical terminology, and the use of tables and graphs at a consolidated level. The conclusion is to incorporate Microsoft Teams as a permanent platform because it promotes timely and continuous monitoring by the faculty, which encourages the mathematical education of the students.

### RESUMEN

#### Palabras clave

Alumnado; enseñanza remota de emergencia; formación matemática; posgrado; valoración estudiantil

*El objetivo de la investigación fue valorar la satisfacción estudiantil sobre su formación matemática en un posgrado en administración a partir de la enseñanza remota durante la pandemia por la covid-19. El enfoque de investigación fue mixto con un diseño secuencial exploratorio. Se elaboró y aplicó un cuestionario a 65 participantes sobre el tipo de dispositivo tecnológico utilizado para continuar su formación académica, las problemáticas enfrentadas y su valoración sobre el nivel de formación matemática. Los resultados mostraron que los alumnos reconocen que durante la época de emergencia vivieron situaciones de carácter logístico, emocional y académico. Se encontraron diferencias estadísticamente significativas debido a que la enseñanza remota promovió la formación matemática mediante el uso eficaz de las videoconferencias, lo que permitió integrar lo aprendido en el desempeño laboral, ayudó en la explicación brindada por el profesorado sobre planeación y adecuación del curso, y benefició el empleo de bases de datos virtuales y la comunicación asíncrona. Además, el estudiantado valoró con un nivel consolidado las competencias orientadas hacia las variables de una situación administrativa, la terminología matemática y el uso de tablas y gráficos. La conclusión es incorporar el uso de Microsoft Teams como plataforma permanente debido a que favorece el seguimiento oportuno y constante por parte del profesorado, lo que incentiva la formación matemática de los estudiantes*

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## INTRODUCTION

The covid-19 pandemic triggered a health crisis that has affected many areas of society globally, including education. Around 1.6 billion students in more than 190 countries were affected when home confinement was decreed (UN, 2020). This scenario forced educational institutions to implement strategies focused on distance education, with the aim of maintaining academic continuity of students at all educational levels; however, this transition gave rise to numerous challenges, ranging from pedagogical and technological issues to emotional well-being situations for the different stakeholders involved (Pedró, 2020; Rosario *et al.*, 2020). This scenario involved the challenge of formulating strategies to generate learning experiences based on digital resources and tools that would enable effective student learning through collaborative work (Restrepo *et al.*, 2020; Delgado and Martínez, 2021).

In this way, since the first semester of 2020, several international studies have been carried out aimed at the incidence of school closures due to the covid-19 pandemic (Cáceres, 2020; Hodges *et al.*, 2020; Lee, 2020; Li, 2020; Reimers and Schleicher, 2020; Unesco, 2020). While the findings indicate the existence of a plurality of strategies through remote emergency teaching, they agree that the pandemic challenges current teaching models by recommending a transition to a new training paradigm, so it has been important to identify both the actions and the incorporated resources that would allow a new culture of teaching at the end of the confinement (Lira and Uribe, 2022; Carrillo *et al.*, 2020).

In this context, it is required that the educational system in the postcovid-19 era be oriented to promote the development of life skills through a change in the ways of teaching and learning content, based on methodologies that promote active learning, projects, for the acquisition, assimilation and processing of new knowledge by students (Sanz and López, 2022).

In the 21st century, the training of administrators at the postgraduate level continues due to the evolution of organizations, which need human talent capable of comprehensively understanding their internal and external behavior, as well as its need for a set of competences to intervene strategically and make decisions (Onete *et al.*, 2014). Also, the various activities of a company require the use of quantitative tools, such as accounting, billing, payroll, preparation and analysis of financial statements, in addition to customer management, which implies a mathematical formation of human capital for the area of administration (Infante-Moro *et al.*, 2015).

Likewise, organizations face a growing volume of quantitative information that is generated on a daily basis, so they demand that their employees have a professional preparation that allows them to select, organize,

analyze and synthesize this information effectively to optimize organizational processes (Lam and McKercher, 2013). Blanco and Franco (2021) say that mathematical competence contributes to the development of other skills in areas such as communication, digital technology, entrepreneurship, sense of initiative and civic attitudes, which are relevant in various fields, both in everyday life and in the working environment.

In this regard, Paris *et al.* (2014) indicate that vocational training also requires the learning of mathematical skills because they provide students with new knowledge to perform successfully in the workplace. For their part, Turner *et al.* (2015) mention that the mathematical training with its respective evaluation focuses on six elements of professional competence: 1) the understanding and communication of statements with mathematical information, 2) the understanding and use of symbols and formal structures of mathematical language, 3) the mathematical approach or translation into mathematical models of problematic situations, 4) the decoding and use of mathematical representations, 5) the selection and use of strategies to solve mathematical problems, and 6) mathematical reasoning and argumentation.

In turn, in order to achieve quality mathematical training in graduate students it is necessary to consider academic and work profiles, as well as their skills and attitudes towards this subject; therefore it is recommended to use pedagogical approaches that include problematization, construction and reflection in the mathematical field, where teachers are a guide to encourage student participation based on their informal conceptions and strategies based on their previous knowledge (Van den Heuvel-Panhuizen and Drijvers, 2014).

Therefore, mathematical formation implies the ability to formulate, use and analyze from a quantitative perspective the situations that a person faces, which includes using reasoning through concepts and procedures that result in the understanding of data and selection of tools that enable the use of a resolution strategy. Thus, the importance of mathematics lies in describing, predicting and explaining phenomena for decision-making based on critical thinking and systematic knowledge, which are fundamental to achieve the potential of students at any educational level (Mamani *et al.*, 2023).

Campaña *et al.* (2019) and González y Fuentes (2011) mention that one of the priority areas to achieve quality learning is to incorporate practical training in students during the delivery of courses. In this sense, the design and implementation of didactic activities that enable students to assimilate contents in contextualized situations to the productive environment where they work is relevant (Lupi3n and Caracuel, 2021). It is therefore necessary to conceive of learning as a dynamic phenomenon related to the transformations and contexts in which students live, so that their participation becomes the fundamental axis that not only drives the

development of their competences, but also their commitment and responsibility in their educational process (Hernández, 2018).

The coronavirus pandemic led to a transformation of teaching in higher education from a face-to-face model in which learning is built through technology. In this context, the results of e-learning should not differ from the face-to-face mode if the following components are met: that online learning activities are consistent with both methodology and content; that these are adapted to be taught with digital tools; that teachers have the appropriate training, as well as that students have the knowledge, skills and attitudes necessary to continue their distance education (Cabero and Llorente, 2020).

Barakhsanova *et al.* (2020) found that during the covid-19 pandemic, students at the graduate level faced various learning difficulties, among which lack of communication with their peers stands out (90%), lack of time to complete school assignments (85%), connection problems (85%) and the challenge of distance learning (75%). In contrast, among the benefits of distance learning participants highlighted the possibility of studying using a computer (100%), the opportunity to learn at home (80%) the availability of digital teaching material for independent consultation (60%) and flexibility of time (35%).

Göksu *et al.* (2021) and Blanco y Blanco (2021) identified that the main psycho-demographic variables that affect the motivation of students in higher education during the covid-19 pandemic in their academic formation are: stress, anxiety, depression, sadness, insecurity and lack of control, which has affected school activities in a negative way due to social isolation. These authors also found that online collaborative work was moderate and that there were difficulties in communicating with the other members.

Baptista *et al.* (2020) found that during the pandemic most of the postgraduate professors carried out processes of information management, collaborative work with their peers and managers, so they have focused on the creation of digital teaching resources, and integrate active methodologies such as the inverted classroom.

Castilla-Alcalá *et al.* (2021) state that the key components of a course in remote teaching at the postgraduate level are: an initial presentation based on videos and PowerPoint presentations, supporting material (reading articles, books or videos provided by teachers), learning activities aimed at applying mathematical concepts and procedures in specific situations, and assessment activities designed to measure students' mastery of course content. In addition, they suggest that the digital teaching resources used during remote teaching be reused for a hybrid mode.

Delgado and Martínez (2021) determined that 72.5% of higher education students have continued their classes through institutional platforms, 58.1% have used WhatsApp, 57.9% email and 13.2% virtual sessions, so they suggest making a migration of content to these technological tools that serves as support in the academic training of students.

Lira and Uribe (2022) found that the most used digital tools by higher education teachers were asynchronous learning platforms with 68.96%, while the use of videoconferences registered 65.78%. They also identified that the means by which students learned the most was: videoconferences (65.51%) and activities on digital platforms (39.78%), as well as communication by e-mail, social networks, WhatsApp and even telephone calls (39.52%). Meanwhile, the sources of information used were documents and books available at home (40.84%), consultation of libraries and virtual databases such as EBSCO or Google (30.50%) and tutorials (25.46%).

In particular, in the case of mathematics, the incorporation of technological tools has diversified both teaching strategies and teaching resources and learning activities. This has not only expanded coverage, but has also encouraged the participation of students in their educational training (Kuo *et al.*, 2012); however, there is still a gap between mathematical learning and the real-life application of students, especially at the postgraduate level (Saadati *et al.*, 2015).

To reduce this gap, it is essential to recognize that the construction of distance learning environments during a contingency requires considering the diverse responsibilities and commitments of the student body, differentiating that the space-time is dynamic and not placed to specific sessions, integrate various sources of information and encourage both participation and collaborative work (Cobo *et al.*, 2020).

However, Wajdi *et al.* (2020) identified difficulties in the mathematical formation of graduate students, among which were the lack of clear explanations, or exercises and problems to solve, which resulted in a deficiency in learning. In addition, they noted insufficient infrastructure, teacher training focused on face-to-face, limited time to plan appropriate distance learning activities and the need to address personal responsibilities during confinement.

Naidoo (2020), in his research on mathematical training at the postgraduate level, states that the integration of technological tools allowed effective communication with teachers, plus unlimited access to and use of the subject's digital teaching resources during the semester. He also notes that the discussion forums facilitated a constant peer review, which allowed identifying errors and understanding mathematical concepts and procedures. In addition, collaborative work was promoted in the resolution of course activities.

Based on the scenario of emergency remote teaching, the National Polytechnic Institute (IPN, by its acronym in Spanish), Mexico, implemented the Virtual Plan of Academic Continuity in order to continue the educational service in an online collaborative learning environment (IPN, 2020a). For the graduate level, spaces were used in the Microsoft Teams platform.

Thus, the research focused on the Master of Science in Business Administration taught by the IPN, which aims to train middle and senior professionals to design and implement management strategies aimed at organizational development, which in turn allow raising productivity and seeking continuous improvement in the business sector (IPN, 2020b). This educational program integrates three training axes in the curriculum: 1) administrative, 2) research and 3) mathematical.

The latter focuses on the formulation, use and interpretation of quantitative techniques and models for decision-making in organizations. In this way, during their first school period the students take the subject of mathematics applied to the administration.

Frick *et al.* (2009) and Lumpkin *et al.* (2015) indicate that student perception is a representative indicator of teaching quality. In addition, student assessment studies focused on the use of methodologies and platforms are equally relevant, as they provide valuable information for the field of didactics (Ballesta-Pagán *et al.*, 2011), and even its results can contribute to educational innovation (Beaudry, 2022; Cavanag *et al.*, 2016).

Therefore, student satisfaction is important for educational organizations, as it provides information on the functionality, liking, interest and relevance of the course taught, while determining whether learning experiences are applicable in the working environment (Abbasi *et al.*, 2020; Gavrilis *et al.*, 2020). Based on the above, the objective of this study was to assess the satisfaction of students with their mathematical training in a postgraduate course in management that was carried out through emergency remote teaching during the pandemic by covid-19.

## METHODOLOGY

This study was conducted under a mixed methodology based on an exploratory sequential design (Creswell, 2015), with emphasis on quantitative analysis with correlative scope because it was oriented to measure the association between two variables: emergency remote teaching and mathematics training at the postgraduate level. From the qualitative point of view, it focused on identifying students' formative experiences.

This research uses a quasi-experimental design based on a case study as an inquiry strategy. This approach allows the researcher to analyze more deeply a program, event or process that involves one or more people (Creswell, 2009). It examines emergency remote teaching at the postgraduate level and its impact on the promotion of students' mathematical training. It is a synchronous or contemporary case due to the topicality and relevance of the subject, whose results may be useful for future research (García-Valcárcel, 2015).

The study participants were students enrolled in IPN who began their postgraduate training in management in the course of Mathematics applied to administration. The sample was non-probabilistic with the criterion for convenience, with a total of 65 participants distributed in three groups (G1, G2 and G3) whose general characteristics are shown in Table 1.

**Table 1.** Study participants

Variable		n
Gender	Female	37
	Male	28
Age (years)	25 a 29	30
	30 a 34	15
	35 a 39	10
Work experience (years)	0 a 4	32
	5 a 9	23
	Más de 9	10

As shown in Table 1, the female gender has a greater participation (57%), the age range of 25 to 29 is the most represented (46%) and the work experience that stands out is between 0 and 4 years (49%).

The information was collected through a questionnaire organized by the variables of emergency remote education and mathematical training, whose structure was: 1) demographic data; 2) type of technological device and time of use per day; 3) problems faced; 4) evaluation of emergency remote teaching on academic continuity with items measured by a four-point frequency scale: totally disagree (DM=1), disagree (D=2), neither disagree nor agree (DA=3), agree (A=4) and fully agree (TA=5), which were converted to a numeric value in order to obtain a quantitative measure; 5) level of mathematical formation with scalar endpoints ranging from 0 (not developed), 1 (insufficient), 2 (regular), 3 (developed) and 4 (consolidated), where the results were interpreted under the following criteria: 0.00 to 1.00 as undeveloped competition, 1.10 to 2.00 as insufficient development, 2.10 to 3.00 as regular development, and 3.10 to 4.00 as consolidated development; and 6) open-ended questions (A, B, C and D) regarding their training experience under remote emergency teaching.

The test of validity of the content of the questionnaire was conducted through the judgment of seven experts, of whom four have more than fifteen years of teaching experience in the subject of Mathematics at the postgraduate level, two of them have ten years working on the construction and validation of instruments for the quantitative approach and one has 20 years' experience in the preparation of research projects on academic training at the postgraduate level. From this process, changes were made to the clarity and wording of each of the statements in the questionnaire. Subsequently, the reliability measurement was carried out where a Cronbach alpha coefficient of 0.886 was obtained, which indicates a good degree of internal consistency and, therefore, reliable. The application of the tool was made by e-mail, where participants were informed of the objective and relevance of the study and were guaranteed the confidentiality of the information obtained. Similarly, the data collection process was carried out after the course was completed in order to avoid possible bias in the study.

At the end of the information collection, the quantitative data obtained by tabulation of each statement were analyzed using descriptive statistics such as mean (M) and standard deviation (SD) with the intention of interpreting the results. In order to determine the normality of the data, the Kolmogorov-Smirnov (K-S) goodness-of-fit test was used, which allowed us to verify that it is indeed met ( $Z = 0.567$ ,  $p = 0.216$ ), so we used the Student  $t$  parametric tests for related samples, as well as the Pearson correlation coefficient  $r$  with a significance level ( $p$ -value) of 0.05. In addition, the Hake factor (1998) ( $g$ ) was calculated, which determines the gain in conceptual learning by equation (1):

Equation:

$$g = \frac{\text{posprueba}(\%) - \text{preprueba}(\%)}{100 - \text{preprueba}(\%)} \quad (1)$$

The importance of this factor is to indicate the effectiveness of a methodology, strategy or approach used for learning, so it is based on the following criteria: a) low ( $g \leq 0.3$ ), b) average ( $0.3 < g \leq 0.7$ ), and c) high ( $g > 0.7$ ). To carry out this quantitative phase, SPSS version 25 was used. For the qualitative phase the answers of the four open questions of the participants were organized in order to determine the relevance, the benefits and difficulties experienced by graduate students in relation to emergency remote teaching.

## RESULTS

Regarding the type of device used by graduate students, it was found that 78% use a laptop, 18% a computer and 4% a cell phone. In addition, an average connection time of six hours was recorded, representing 88% of the total time. Regarding the situations faced by participants during the emergency period, 92% were of a logistical nature (planning and organization of work, academic and family activities), 70% of emotional type (feelings of frustration, sadness, discouragement and even anxiety) and 44% corresponds to academic aspects (fulfillment in time and form of training activities).

Subsequently, the results obtained by the  $t$  test indicate the existence of statistically significant differences, both by group and overall, so it follows that the evaluation of emergency remote teaching has an effectiveness in mathematical training, as shown in Table 2.

**Table 2.** T-test for related samples by group and total.

Group	n	Pretest		Posttest		T-tes	
		<i>M</i>	<i>DE</i>	<i>M</i>	<i>DE</i>	<i>t</i>	<i>p</i>
G1	22	5.47	2.97	9.32	0.88	6.735	0.000
G2	20	5.88	2.32	9.47	0.56	6.591	0.000
G3	23	5.23	3.11	9.55	0.48	6.865	0.000
Total	65	5.53	2.80	9.45	0.64	6.688	0.000

Students' assessments of academic continuity based on emergency remote teaching at the postgraduate level for the subject of mathematics are shown in Table 3.

Student assessments of academic continuity during confinement indicate that the highest scores were the effective use of videoconferences by Microsoft Teams ( $M = 4.95$ ) as a communication tool for the development of the various synchronous sessions of the course. This is explained by the course adaptation strategy of the teachers ( $M = 4.94$ ), who selected and incorporated virtual databases ( $M = 4.93$ ), as well as the planning and presentation of the course to the student ( $M = 4.92$ ). As a result, it is possible to infer the existence of a teaching accompaniment in a constant and timely way by e-mail and WhatsApp ( $M = 4.91$ ), which contributed to the achievement of the objectives ( $M = 4.91$ ) and the integration of learning into work performance ( $M = 4.95$ ).

**Table 3.** Student evaluations

<b>Emergency remote teaching allowed</b>	<i>M</i>	<i>DE</i>
Explain the subject plan at the beginning of the course	4.92	0.25
Describe the course adaptation strategy during confinement	4.94	0.22
That virtual activities promoted the formation of mathematical skills	4.90	0.21
That the digital teaching resources used were sufficient and appropriate	4.88	0.29
That teaching intervention was permanent during confinement	4.23	0.48
Timely communication via email and WhatsApp	4.91	0.24
The effective use of video conferencing by Microsoft Teams	4.95	0.19
Use virtual databases like EBSCO	4.93	0.21
Employ a formative assessment	4.33	0.79
Archieve course objectives	4.91	0.24
Promote collaborative work	4.52	0.61
Achieve active learning	4.83	0.38
Integrate what has been learned into work performance	4.95	0.19
Quality in vocational training	4.91	0.24

These findings indicate that remote emergency teaching allowed continuing academic training for graduate students. This was achieved by achieving the objectives of the course and carrying out learning activities based on prior consultation of digital teaching resources, such as access to the EBSCO virtual database, which fostered interaction and collaborative work among participants.

In this sense, it should be noted that using the tool Microsoft Teams was important to carry out synchronous virtual sessions in combination with asynchronous communication by email and WhatsApp, which allowed teachers to resolve doubts, review progress and comment on strategies proposed by students.

In addition, it is important to note that the implementation of a formative evaluation focused on the development of mathematical competences, oriented to the process of understanding the administrative situation, selection of variables, formulation and argumentation of strategies for solving and interpreting the results, highlighted the relevance of the contents that can be applied in the work environment of students, so that they recognize the quality of their educational training.

The findings of the mathematical formation of graduate students during confinement are shown in Table 4.

**Table 4.** Student assessment of the their mathematical training

<b>Emergency remote teaching built capacity to</b>	<b><i>M</i></b>	<b><i>DE</i></b>
Identify the variables of an administrative	3.95	0.19
Use mathematical terminology	3.84	0.23
Reason mathematically	3.25	0.51
Formulate a strategy	3.34	0.42
Argue mathematically	3.15	0.68

Use tables and graphs in spreadsheets	3.72	0.34
Interpret the results for an administrative situation	2.88	0.88

Assessment of postgraduate students in administration regarding their mathematical training stands out in several aspects. First, the highest means were obtained in the ability to identify the variables of an administrative situation ( $M = 3.95$ ), the use of mathematical terminology ( $M = 3.84$ ) and the ability to use spreadsheets when producing tables and graphs ( $M = 3.72$ ). These results show that participants recognize the effectiveness of the course based on remote emergency teaching. Second, there are skills related to strategy formulation ( $M = 3.34$ ), mathematical reasoning ( $M = 3.25$ ) and argumentation ability ( $M = 3.15$ ). It follows that these competences are in a state of development according to the perception of the students, which implies that activities aimed at their consolidation are required.

Third, the student assessed with the lowest average score the ability to interpret the results for an administrative situation ( $M = 2.88$ ), which is explained because it is a skill with gradual appropriation, that is, it requires the development of other skills such as analysis and synthesis of quantitative information, as well as formulating a strategy. This indicates that it is necessary to design and implement training strategies that strengthen this ability during their stay at the graduate level.

The parametric test of the Pearson correlation coefficient  $r$  is shown in Table 5. A significant direct association between the two variables of the research is presented ( $r = 0.879$ ,  $p = 0.000$ ), which corroborates that remote emergency teaching in a postgraduate course in management has influence to promote the mathematical formation of students from the strategy of adequacy, the use of databases and the timely and constant monitoring of teachers through synchronous and asynchronous communication tools.

**Table 5.** Correlation between variables

Variable	Mathematical training	<i>p</i>	95% IC	
			LI	LS
Emergency Remote Teaching	0.879	0.000	0.758	0.936

The results obtained from the Hake factor (*g*) appear in Table 6. The existence of a gain in average learning for the first group is determined, which is possibly because its members have a lower level of previous knowledge obtained in the pre-test, while for the other two it is classified as a high level. When considering all participants, a value  $g = 0.72$  is obtained, which confirms that emergency remote teaching is effective in the mathematical training of postgraduate students in administration.

**Table 6.** Hake factor results

Group	n	Pretest	Posttest	<i>g</i>
		% of correct answers	% of correct answers	
G1	22	34.48	80.12	0.69
G2	20	30.15	82.65	0.75
G3	23	32.88	81.46	0.72

### *Findings of the open questions*

For the question: "what are the benefits of using technological tools in academic training?" , students indicated the flexibility to review materials in advance, the ability to manage their own schedules and plan their activities, together with encouraging greater motivation and participation during each of the virtual sessions as they experienced during face-to-face classes before the pandemic. The above is complemented by quantitative data collected on the type of device and time used: 80% of the participants have as main medium the laptop, 15% the desktop computer and 5% the cell phone. About the type of internet connection, 95% use a fixed connection and 5% a mobile. In relation to the time spent daily during confinement to their postgraduate training, 5% spent one hour, 10% two hours and 80% three or more hours. The relevant testimonies are shown in the following narrative:

Participant 15: Provides easier access to study materials.

Participant 38: Time to review and analyze virtual resources from anywhere.

Participant: 56: Your consultation is anticipated to meet the participation in the virtual session.

Participant 64: It allows to identify the topic to be addressed that motivates to inquire in other sources, as well as to participate in a similar way if you were in the presence.

Participant 67: Promotes an active role in learning that leads to greater responsibility for academic education.

As for the question: "what is the main advantage of emergency remote teaching?" , graduate students mentioned, among others, the ability to fulfill their responsibilities, not only of their academic and labor training, but also of their personal commitments. They also pointed out that it allows them to connect from anywhere else without having to move to a classroom, which implies additional time. They also established that it encourages the development of other attitudes such as adaptation to change, openness and time management.

Participant 3: The use of digital tools.

Participant 26: The development of attitudes of coping, openness and adaptation to change.

Participant 38: The possibility of complying with school and work activities from organizing schedules.

Participant 46: Do not move to school.

Participant 69: The alternative of connecting to the virtual class from another space, be it work or home.

In the question: "what is the main formative activity that would rescue for its incorporation once the confinement ends?" , participants mention various actions that remote emergency teaching implemented in an effective and timely manner, and that are also relevant to be incorporated in the period after confinement: study materials (journal databases, digital library archives, videos and presentations produced by teachers), which are useful teaching resources for students as they encourage online communication and interaction, promote collaborative work and contribute to the successful completion of course tasks.

Also, the constant and timely presence of teachers throughout the educational process contributed to quality mathematical training. Its main actions include synchronous and asynchronous communication with students during the course. In addition, teachers reviewed each of the activities delivered by the students in order to provide recommendations. In addition, communication through various media such as email, WhatsApp and Microsoft Teams enabled the monitoring and attention during the implementation of the course among the participants.

Participant 18: Prior consultation of the study materials that motivate you to look in other information sources for the topic to be addressed.

Participant 32: The continuous evaluation of the course by the teachers.

Participant 41: The communication between the members in synchronous and asynchronous form during the course.

Participant 64: Interaction between colleagues from their personal or work space in a virtual way.

Participant 70: Teamwork that fostered responsibility and exchange of ideas to develop the deliverable.

Faced with the question: "what is the main difficulty experienced during remote emergency teaching?" students recognized that these problems ranged from technology to the personal level, in addition to highlighting connectivity and the use of technological equipment, lack of organization of activities and even emotional situations. This corroborates what the students indicated in the data collected by the questionnaire, where it was identified that 89% of the conflicts faced were socio-affective (sadness, anxiety, frustration and other health problems), 81% logistic type (time management, organization of physical spaces), 72% technological type (internet access and provision of computer equipment) and 45% educational type (knowledge of technological tools, remote participation and sending activities).

Participant 7: Lack of connectivity in the home continuously.

Participant 19: The feeling of confinement that generated anxiety, coupled with the resistance to adapt to change.

Participant 28: Have to perform various activities simultaneously.

Participant 47: Have only one electronic team and have to share it with more family members.

Participant 72: The emotional discomfort generated by the uncertainty of not knowing how long the confinement would last.

## DISCUSSION

Research results indicate that emergency remote teaching is effective to encourage mathematical training in the students of a postgraduate degree in administration, because it allows the use of an institutional platform such as Microsoft Teams, determinant for performing synchronous virtual sessions, in addition to accessing databases. In addition, a constant and timely teaching support is highlighted through e-mail and WhatsApp, which allowed achieving the objectives of the course and integrating learning, strategic elements to position or improve in the labor sector (Paris *et al.*, 2014; Infante-Moro *et al.*, 2015). It is also important to note that the formative evaluation has led to the identification of the contents that can be incorporated in the labor field of the students, who recognize the quality of their educational formation, which is aligned with the investigations of Frick *et al.* (2009) and Lumpkin *et al.* (2015) that student perception is a representative indicator of teacher quality.

Likewise, it confirms what was established by Mamani *et al.* (2023) and Lam and McKercher (2013) on the relevance of vocational training that promotes selection, organization, analysis and synthesis by the human capital of an organization that allows it to make decisions based on critical thinking and systematic knowledge. Based on the above, the postgraduate level complies with what Onete *et al.* (2014) indicated, in that the training of administrators is oriented towards understanding the behavior of organizations to intervene strategically.

In this sense, the results obtained from this research confirm the points made by Ballesta-Pagán *et al.* (2011) on the relevance of student assessment in the use of didactic platforms and methodologies to determine their effectiveness and usefulness to promote student learning, as well as to identify learning experiences (Abbasi *et al.*, 2020; Gavrilis *et al.*, 2020). Thus, remote emergency education allowed continuing the academic training of graduate students, meet the objectives and carry out learning activities based on prior consultation of digital teaching resources, such as access to the EBSCO virtual database, which fostered collaborative work among participants.

It also confirms the provisions of Lupión y Caracuel (2021), Hernández (2018) and González y Fuentes (2011) on the importance of designing and

implementing practical activities that allow students to acquire knowledge in contexts related to administration, through participation mediated by technological tools, as well as working collaboratively with other participants.

In addition, it agrees with the report by Lira and Uribe (2022) and Delgado and Martínez (2021) regarding the permanent use of communication tools and videoconferences at the graduate level, as well as virtual databases, recognizing its effectiveness in promoting mathematical formation. It highlights the role of teachers during this training process, who not only had a constant follow-up, but also carried out a formative evaluation, which is confirmed by what was indicated by Van den Heuvel- Panhuizen and Drijvers (2014) and Kuo *et al.* (2012).

On the other hand, it differs from what Wajdi *et al.* (2020) in the deficiencies in the mathematical learning of students due to the lack of follow-up and training activities by teachers, since in this study at the graduate level the opposite happened: its high responsibility and commitment was highlighted, as well as the openness to change to remote emergency teaching. In addition, in contrast to what was reported by Barakhsanova *et al.* (2020), who claim that students had problems communicating with their peers, lack of time to perform school activities and a negative experience of studying remotely, in this research the perception by graduate students is favorable. It also differs from Saadati *et al.* (2015) in the lack of real application of mathematical training at the postgraduate level.

It should be noted that during the confinement both teachers and students faced a set of educational, technological, attitudinal and emotional difficulties at the graduate level, due to the abrupt transition from presence to virtuality, which confirms what Göksu *et al.* (2021), Cáceres (2020) and Rosario *et al.* (2020) have stated. Similarly, it coincides with what was investigated by Blanco y Blanco (2021) in that the confinement generated a social isolation and caused havoc in the school and personal performance of students; however, according to the results of this study, participants generated attitudes of coping, openness and adaptation to change.

In general terms, the results found in this research confirm what was established by Cobo *et al.* (2020), Cabero and Llorente (2020) and Carrillo *et al.* (2020) that technological tools are effective because they promote a learning process remotely by using digital teaching resources in combination with asynchronous and synchronous activities through collaborative work. There is also an adaptation and consistency between the contents, learning activities, methodology and evaluation carried out by the teaching staff, which contributed to the achievement of the objectives of the mathematics subject at the postgraduate level. From the students' perspective, this experience was characterized by its quality and

the possibility of successfully transferring the knowledge they acquired to the workplace.

Therefore, the suggestion of Castilla-Alcalá *et al.* (2021) that the digital teaching resources used during the confinement be reused at the end of this period is corroborated. It is agreed with Beaudry (2022) and Cavanag *et al.* (2016) that their findings are contributions to educational innovation.

## CONCLUSIONS

The results of this research determine that remote emergency teaching implemented during the pandemic by covid-19 is useful and relevant to promote the mathematical training of graduate students in management, so the overall objective was achieved. In this sense, this study provides conclusive data because it considered the assessment of students as an important element of the quality with which an educational program is taught at the postgraduate level, specifically in the field of management knowledge.

Thus, student satisfaction in the postgraduate degree in administration is an indicator that reflects the effectiveness of various aspects, such as the platform used, the academic monitoring provided by the faculty, the use of teaching resources and learning experiences. Thus, this research offers relevant information on the experiences of students at this educational level, considering not only academic aspects, but also the experiences they have had during confinement, including logistical aspects, work and personal.

The evaluations carried out by the participants suggest that the training received through remote emergency education has proven to be transferable and useful in the workplace, which highlights its quality. Consequently, the findings of this research will be useful to consider the possibility of migrating content from the graduate level to virtual platforms such as Microsoft Teams, that being an institutional tool allows the student to consult support resources for their training and carry out activities in a collaborative manner. It should be noted that this study contributes to the design of care strategies aimed at the emotional well-being of students, with the guidance of specialized professionals.

Finally, it is important to highlight the limitations of this research. First, the sample size is small, as it focuses on students starting a postgraduate degree at a single educational institution. Secondly, it is limited to the evaluation of a single semester of the course. Finally, the perspective of teachers is not considered in the analysis. In this sense, it is recognized the need to replicate these results in a broader and diverse sample, in order to

obtain and contrast more significant findings. It is also suggested to conduct research focusing on the socio-emotional aspect of the actors at the postgraduate level during the pandemic caused by covid-19.



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